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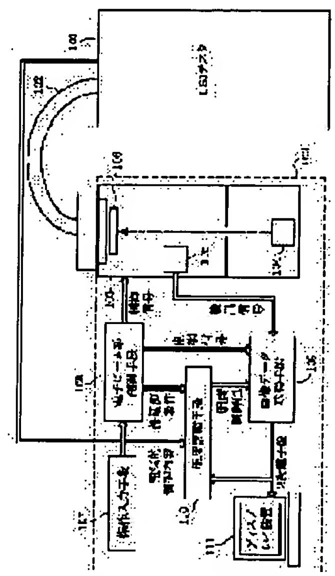
(54) **DEVICE AND METHOD FOR OBSERVING SECONDARY ELECTRONIC IMAGE**

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a device which automates a means that adjusts the light ness and contrast of a display device, when an acquired secondary electron image is displayed on the display device for improving the efficiency and speed of failure analysis, etc., using an electron beam tester.
SOLUTION: A lightness adjusting means 110 draws the initial value of a lightness control value, based on the contents of electric control supplied from an LSI tester 101 to a semiconductor element 106 to be tested and image observing conditions drawn from the contents of control supplied from an electron beam system control means 108 to an electron beam system (a electron beam generating source 104 and a secondary electron detector 105). At drawing of the initial value, the means 110 preaquires such data that indicate the correlation between the variation of the contents of electric control and image observing conditions and draws out a value, which is appropriate as the initial value of the lightness control value of a new secondary electron image, by referring to previously observed secondary electron images and the lightness control values at that time.



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* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the image observation method performed using the secondary electron image observation equipment and it which were made as [perform / lightness adjustment / automatically / as especially image observation can carry out in the state of suitable lightness / about the observation method of the equipment which observes the image of the secondary electron which irradiates an electron beam on the surface of a semiconductor device, and is generated by this, and a secondary electron image,].
[0002]
[Description of the Prior Art] Conventionally, the electron beam tester (electron beam tester) is used as one of the failure analysis of a semiconductor device, or the effective meanses of device design verification. An examined semiconductor device is carried in a vacuum chamber, and it irradiates, scanning an electron beam to a part of examined semiconductor device two-dimensional, and the secondary electron image which expresses the configuration of an examined semiconductor device by the shade can be acquired by measuring the amount of secondary electrons which this generates. The secondary electron image which expresses the potential distribution of an examined semiconductor device front face by light and darkness by acquiring a secondary electron image can be acquired impressing supply voltage and a test vector sequence to an examined semiconductor device by the LSI circuit tester etc. especially, relative potential can be read in the gradation about each wiring in it, and High or Low can be judged when it is especially the logic LSI. Thus, failure analysis and analysis of operation can be performed by checking the potential of operation inside a semiconductor device.
[0003] In this case, the watcher has performed adjustment of the lightness on the display picture of a secondary electron image with hand control conventionally. Drawing 7 is the block diagram showing the composition of conventional secondary electron image observation equipment. In this drawing, 700 of a point within the limit is an electron beam tester, and 701 is an LSI circuit tester. In the electron beam tester 700, it has the vacuum chamber 703, the secondary electron detector 705 is arranged with the electron beam generation source 704 in the interior, and the electron beam system is constituted by these. Into the vacuum chamber 703, the examined semiconductor device 706 is placed as a candidate for observation. The fixture and the interconnection cable 702 connect between the examined semiconductor device 706 and the LSI circuit tester 701. The electron beam tester 700 is further equipped with the operation input means 707, the electron beam system control means 708, the image data acquisition means 709, and the display unit 711.
[0004] To the examined semiconductor device 706, supply voltage and a test vector sequence are impressed from the LSI circuit tester 701 through a fixture and an interconnection cable 702. According to the content of an operation input by the watcher in the operation input means 707, the electron beam system control means 708 control physical operation and secondary electron detection of electron beam irradiation etc., and control secondary electron image acquisition. Under this control, from the electron

beam generation source 704 in the vacuum chamber 703, an electron beam is generated and it scans including the Observations Department grade of the front face of the examined semiconductor device 706. A secondary electron occurs according to the surface configuration and surface potential to scan, and the secondary electron detector 705 incorporates the secondary electron which this generated, and counts the amount of secondary electrons. And it sends to the image data acquisition means 709 by making this measurement value into a detecting signal.

[0005] The image data acquisition means 709 receives the detecting signal from the secondary electron detector 705, and forms a secondary electron image in the bottom of control of the electron beam system control means 708 based on the lightness control value inputted from the operation input means 707. The information is sent to a display unit 711, and is displayed as a picture. A watcher views this image display and the suitable contents of correction are inputted into the operation input means 707.

[0006]

[Problem(s) to be Solved by the Invention] As for the secondary electron image mentioned above, overall lightness and contrast of an image are sharply changed by the electrical condition (****** [impressing supply voltage] etc.) of an examined semiconductor device, the conditions of image observation, the histories (the conditions of the image formation from the electron beam irradiation method and the amount of secondary electrons, the range for observation of an examined semiconductor device, etc.) of beam irradiation, etc. Furthermore, a lightness distribution of a secondary electron image will change, even while continuing observation of the same conditions. It is because the density of the electron of an examined semiconductor device front face changes and lightness and contrast change with elapsed time by continuing irradiation of an electron beam. Since an electron beam will irradiate the narrow range when a scale factor is gathered and observed especially, the density of a beam increases and this phenomenon becomes more remarkable. When the secondary electron image which is not suitable is acquired, on the whole, a lightness distribution inclines toward black or white, and it becomes impossible to read clearly the configuration of the examined semiconductor device front face originally needed, and a potential distribution.

[0007] In this case, when image observation is being performed on real time, it is possible to perform lightness adjustment manually, observing an image and to acquire suitable lightness. However, in failure analysis, a huge test vector sequence is impressed by the LSI circuit tester, and secondary electron image acquisition is performed in many cases only synchronizing with the test vector of the specific turn in it. In this case, although a test vector sequence will be impressed repeatedly and only the image data of specific timing will be acquired and accumulated in one data acquisition since the picture of high S/N cannot be acquired, since operation of reaccumulating image data must be repeated and must be again performed with another control value after doing in this way and accumulating when lightness is not appropriately adjusted in this observation mode, efficient failure analysis cannot be performed. Then, to automate adjustment of lightness and contrast for more efficient failure analysis is desired. Therefore, the technical problem of this invention is enabling it to adjust lightness and contrast of a secondary electron image quickly and automatically.

[0008]

[Means for Solving the Problem] The electron beam system which equips an examined semiconductor device with the electron beam generation source which irradiates an electron beam, and the secondary electron detector which detects the generated secondary electron according to this invention in order to solve the above-mentioned technical problem, The electron beam system control means which control the aforementioned electron beam system, and the LSI circuit tester which impresses supply voltage and a test vector sequence to an examined semiconductor device, An image data acquisition means to supply a secondary electron picture signal to the aforementioned display unit based on the detecting signal of the aforementioned secondary electron detector in order to display a secondary electron image on a display unit, It has a lightness adjustment means to direct the lightness of the secondary electron image which gives a lightness control value control value to the aforementioned image data acquisition means, and is displayed on a display unit. the aforementioned lightness adjustment means The contents of the supply

voltage which the aforementioned LSI circuit tester supplies to the aforementioned examined semiconductor device, and a test vector sequence are received as contents of electric control. And/ Or the contents of the control signal which the aforementioned electron beam system control means give to the aforementioned electron beam system are received as image observation condition data, and secondary electron image observation equipment ** characterized by creating the lightness control value given to the aforementioned image data acquisition means with reference to these data is offered.

[0009] Moreover, according to this invention, in order to solve the above-mentioned technical problem, the supply voltage and the test vector sequence which an LSI circuit tester impresses to an examined semiconductor device are supervised as contents of electric control, and when the data of these contents of electric control change, secondary electron image observation method ** characterized by adjusting the lightness of the secondary electron image displayed on a display unit corresponding to the change is offered. And the image observation conditions which electron beam system control means give to an electron beam system are supervised preferably, and when the image observation condition is changed, the lightness of the secondary electron image displayed on a display unit according to the change is adjusted. Moreover, preferably, the electron beam irradiation time to the Observations Department grade of an examined semiconductor device is supervised, and the lightness of the secondary electron image displayed on a display unit according to the time is adjusted.

[0010]

[Embodiments of the Invention] Next, the form of operation of this invention is explained in detail with reference to a drawing.

[Form of the 1st operation] drawing 1 is the block diagram showing the form of operation of the 1st of this invention. a portion equivalent to the portion of the conventional example shown in drawing 6 in this drawing -- lower -- the reference number in which 2 figures is common should give -- ********** In the form of this operation, in the electron beam tester 100, the lightness control value which directs the lightness of the secondary electron image displayed on a display unit 111 is created, and a lightness adjustment means 110 to output this to the picture acquisition means 109 is established.

[0011] The LSI circuit tester 101 sends the contents of electric control (existence of power supply impression, address information of the test vector sequence to impress, etc.) given to the examined semiconductor device 106 for control value derivation of the lightness in the lightness adjustment means 110 to the lightness adjustment means 110. The electron beam system control means 108 send the control signal for controlling physical operation and secondary electron detection of electron beam irradiation etc. to an electron beam system according to the contents of an input of operation by the watcher in the operation input means 107. Under this control, from the electron beam generation source 104 in the vacuum chamber 103, an electron beam is generated and it scans including the Observations Department grade of the front face of the examined semiconductor device 106. A secondary electron occurs according to the surface configuration and surface potential to scan, and it is detected by the secondary electron detector 105. Moreover, the electron beam system control means 108 send the control signal for controlling secondary electron image acquisition to the image data acquisition means 109. Furthermore, the electron beam system control means 108 send image observation conditions (the scale factor of image observation, image observation time, etc.) to the lightness adjustment means 110.

[0012] The image data acquisition means 109 receives the content of electron beam system control from the electron beam system control means 108 as a control signal, receives the information on a secondary electron from the secondary electron detector 105 as a detecting signal, and according to the lightness control value from the lightness adjustment means 110, after setting up lightness, it forms a secondary electron image. Refer to the content of electric control from the LSI circuit tester 101 to the secondary electron image formed with the image data acquisition means 109, and the examined semiconductor device 106, and the image observation conditions in the electron beam system control means 108 for the lightness adjustment means 110. Here, the electron beam irradiation time continued by the same field is also contained in image observation conditions. A suitable lightness control value is drawn based on these, and it is sent to the image data acquisition means 109. By sending a suitable lightness control value

by the above procedure, the lightness of a secondary electron image will become good, and from the image data acquisition means 109, a secondary electron image is sent to a display unit 111, and it is displayed as a picture. The secondary electron image created with the image data acquisition means 109 is sent also to the lightness adjustment means 110, and is used here for lightness surveillance.

[0013] In addition, the vacuum chamber 103, the electron beam generation source 104, the secondary electron detector 105, the electron beam system control means 108, the image data acquisition means 109, and a display unit 111 should just be mechanisms equivalent to the thing in the electron beam tester 100 marketed. However, in the electron beam system control means 108 and the image data acquisition means 109, the mechanism of data transmission and reception with the lightness adjustment means 110 is added to the equivalent function in the commercial electron beam tester 100.

[0014] Change is added to the form of the 1st operation mentioned above, and you may make it the lightness adjustment means 110 acquire image observation conditions from the operation input means 107. In this case, the operation input means 107 derives image observation conditions from the contents of operation given to the electron beam system control means 108.

[0015] [Form of the 2nd operation] drawing 2 is the block diagram showing the form of operation of the 2nd of this invention. the portion equivalent to the form of the 1st operation shown in drawing 1 in this drawing -- lower -- the reference number in which 2 figures is common should give -- ********** In the form of this operation, analysis operation is automatically performed by controlling an electron beam tester 200 and the LSI circuit tester 201 by the computer etc. That is, an electron beam system motion-control signal is given to the electron beam system control means 208 from the analysis control means 212 which control the whole automatic analysis operation, and a test control signal is given to the LSI circuit tester 201. From the contents of the test control signal to the LSI circuit tester 201, the analysis control means 212 draw the contents of electric control sent to the examined semiconductor device 206 from the LSI circuit tester 201, and send the data to the lightness adjustment means 210. Moreover, image observation conditions are drawn from the contents of control to the electron beam system control means 208, and it sends to the lightness adjustment means 210. Other composition is the same as that of the form of the 1st operation shown in drawing 1 . It is not necessary to make the need of making image observation conditions outputting from the electron beam system control means 208 according to the composition of the form of this 2nd operation, and the contents of electric control from the LSI circuit tester 201 to the examined semiconductor device 206 output, and if the means of motion control against an electron beam tester 200 and the LSI circuit tester 201 is used, it can carry out, without requiring the special reconstruction to each.

[0016] The example of concrete operation of the secondary electron image observation equipment shown in [Operation] next drawing 1 , and drawing 2 is explained. Drawing 3 is a flow chart which shows the example of the procedure of the lightness adjustment performed by taking and being in the observation equipment shown in drawing 1 and drawing 2 . In advance of image observation, the data which change with the contents of electric control and image acquisition conditions and correlation with the average variation of the lightness control value by the difference of electron beam irradiation time understand beforehand are acquired using the sample semiconductor device etc., and it is stored as a table which should be referred to.

[0017] In case a secondary electron image is observed, in advance of observation, adjustment start instructions are emitted by the lightness adjustment means 108 from the electron beam system control means 108 (or the publication of the reference number of the base of No. 200 is omitted suitably 208 and the following), and the flow of drawing 3 is started. Here, the voltage impressed to the examined semiconductor device 106 in the image (or carried out actually) observation performed last time as an example and the image observation performed from now on changes to 3V from 0V, and a change mentions the case where there is nothing to the other conditions. First, the contents of electric control in the case of the image observation performed last time, image acquisition conditions, and the lightness control value at that time are read and held at Step S1.

[0018] Next, in Step S2, the image observation conditions based on the control signal which acquires the

supply voltage and the test vector sequence which are impressed to the examined semiconductor device 106 as contents of electric control from the LSI circuit tester 11, and is given to an electron beam system from the electron beam system control means 108 about the secondary electron image observation to be performed from now on are acquired from the electron beam system control means 108, and this is held. Subsequently, comparison of the contents of electric control of this time and last time and image acquisition conditions is performed at Step S3. In the case of the above-mentioned example, it is recognized that applied voltage changes to 3V from 0V. And the optimal amount of lightness control value changes corresponding to the difference at Step S3 is calculated at Step S4. For this reason, the contents of the table on which the data showing the optimal amount of lightness control value changes when it changes for every conditions are stored are investigated. The example of data is shown in drawing 4 . A difference of the optimal lightness control value at the time of impression of voltage 3V and powering off is 6. Supposing the applied voltage in the time of the last image observation is 0V and was adjusted to the lightness distribution with the lightness control value optimal at 180, the optimal lightness control value after voltage 3V impression will be drawn as 186 (=180+6).

[0019] The lightness control value drawn at Step S4 is transmitted to the image acquisition means 109 at Step S5, and lightness adjustment operation by the lightness adjustment means 110 is completed. Then, the supply voltage and the test vector sequence which were directed for this observation are impressed to the examined semiconductor device 106 from the LSI circuit tester 101, an electron beam system performs operation which followed the control signal from the electron beam system control means 108, and the detecting signal outputted based on this is sent to the image data acquisition means 109. After this detecting signal is processed into a secondary electron image according to the lightness control value newly inputted in the image data acquisition means 109, it is sent to a display unit 111 and displayed on a screen.

[0020] In observation of a secondary electron image, there is a phenomenon in which lightness changes, by continuing irradiation of an electron beam to the same Observations Department grade. That is, the lightness control value for keeping a lightness distribution of an image the optimal also changes with time. Furthermore, the rate of the change per the same time changes also with scale factors. When gathering the observation scale factor of a secondary electron image, and an electron beam scans a narrow field, it is for the rate of change of the electron density of the examined semiconductor device 106 by the density of the electron of a beam becoming high and continuing irradiation to increase. In this invention, in order to cope with this phenomenon, progress of electron beam irradiation time and a relation with the optimal amount of lightness control value changes are investigated beforehand, and the data is held in the table. With this, the time (second) per variation of the optimal lightness control value for every scale factor is investigated in advance, and the data is held in the table.

[0021] Drawing 5 is the example of the data which expressed the time (second) per variation of the optimal lightness control value for every scale factor. For example, when observing a scale factor in 500 times, the optimal lightness control value will decrease every [0.4] per time. When observation should be continued for this scale factor, the flow of drawing 3 will be performed and the comparison result in Step S3 will perform now image observation in the state where beam irradiation time is long, for 3 seconds from last time, the lightness control value which lowered only 0.4x3= 1.2 in step S4 is drawn.

[0022] Moreover, when carrying out image observation, changing the irradiation position and irradiation time of an electron beam moving the Observations Department grade, amendment is added [as opposed to / a lightness control value / only in the part according to elapsed time and a scale factor after moving the Observations Department grade to the part] with reference to drawing 5 . For example, if the flow of drawing 3 should be performed when it observed after [of an after / the Observations Department grade movement] 5 seconds to Field A and an image was observed for the Observations Department grade by one 500 times the scale factor of this after / of an after / movement] 20 seconds to Field B last time this time In Step S3, there is no change in a scale factor, and a ******** is detected [20-5= 15 (second)] for the electron beam irradiation time in Field B from the irradiation time in Field A. Consequently, the lightness control value which lowered only 0.4(20-5) = 6 from the case of Field A with reference to the

data of drawing 5 at Step S4 is drawn.
[0023] The data shown in [correction of reference table] drawing 4 and drawing 5 show the average value measured and acquired about the sample etc. in advance. However, in other factors, such as a difference of the property of the front face of each examined semiconductor device, and a difference of the state of the filament of an electron beam generation source, for a certain reason, the case where already acquired data are not suitable to substance may happen in fact. Then, after drawing the lightness control value of initial value at the Observations Department grade, it is good to give fine tuning considered to be suitable, to obtain a proper lightness distribution, and to use this result in future lightness adjustments. A concrete procedure for that is shown in drawing 6 .
[0024] In the flow of drawing 6 , since the process to Step S4 is the same as the process shown in drawing 3 , the explanation is omitted. The lightness control value drawn at Step S4 is sent out in Step S5 to the image data acquisition means 109. Here, as explained previously, last image observation should be performed by voltage:0V and lightness control value:180, and 186 should be sent out for this image observation as a lightness control value by applied-voltage:3V. The image data acquisition means 109 creates a secondary electron image (a secondary electron image is specifically bit map data, i.e., the digital data for a pixel) based on the detecting signal of an electron beam system, and the sent lightness control value, and sends this out to a display unit 111 and the lightness adjustment means 110. In Step S6, the lightness adjustment means 109 creates a lightness distribution map, i.e., a lightness histogram, based on the sent secondary electron image. Next, it is judged in Step S7 whether the obtained lightness distribution is proper. This is judged by whether there is any mean value of for example, a lightness histogram within suitable limits. When the suitable lightness distribution is obtained, processing is ended, and when that is not right, it moves to Step S8.
[0025] In Step S8, the variation of the lightness for obtaining a suitable lightness distribution is calculated, and a new lightness control value is drawn based on this. Here, the variation of the lightness for obtaining a suitable lightness distribution is determined by which should change the mean value of for example, a lightness histogram. And the amount of lightness control value changes is determined with reference to the lightness control value variation / lightness variation conversion table currently prepared beforehand. Generally, since a correlation is between the variation from a certain lightness control value, and the variation of lightness, only a certain amount can convert [which should change a lightness control value to changing lightness, and]. Then, in this invention, this conversion table is prepared, and it uses in order to derive a better lightness control value. Next, in step S9, the table for calculating a lightness control value is rewritten based on the newly drawn lightness control value. For example, in the above-mentioned example (applied voltage : 3 V, a lightness control value : 186), when it is determined that a lightness control value should be made 185, the amount of differences of the lightness control value corresponding to 3V of the data shown in drawing 4 is rewritten to 5. Then, it returns to Step S5 and process after it is performed.
[0026] Hereafter, this rewritten table is used and subsequent image observation is performed. That is, it observes, rewriting a table if needed. In addition, although explanation followed the contents of electric control of the data impressed to an examined semiconductor device, it is the same also about the image observation conditions containing electron beam irradiation time.
[0027] As mentioned above, although the form of desirable operation was explained, a proper change is possible for this invention within limits which are not limited to these and indicated by the claim. Moreover, although the form of operation explained as what adjusts only the lightness of a secondary electron image, you may make it adjust the contrast of a picture independently in addition to lightness.
[0028]
[Effect of the Invention] As explained above, since the secondary electron image observation equipment and the method of this invention adjust lightness and contrast corresponding to change of the contents of electric control, and image acquisition conditions, they can conform to change of the contents of electric control, and image acquisition conditions, and can always perform image observation on optimal lightness and contrast conditions. Therefore, according to this invention, device design verification and failure

analysis can be performed efficiently. Moreover, according to this invention, adjustment of lightness and contrast is easily automatable.

[Translation done.]

CLAIMS

[Claim(s)]
[Claim 1] The electron beam system which equips an examined semiconductor device with the electron beam generation source which irradiates an electron beam, and the secondary electron detector which detects the generated secondary electron, The electron beam system control means which control the aforementioned electron beam system, and the LSI circuit tester which impresses supply voltage and a test vector sequence to an examined semiconductor device, An image data acquisition means to supply a secondary electron picture signal to the aforementioned display unit based on the detecting signal of the aforementioned secondary electron detector in order to display a secondary electron image on a display unit, It has a lightness adjustment means to direct the lightness of the secondary electron image which gives a lightness control value control value to the aforementioned image data acquisition means, and is displayed on a display unit. the aforementioned lightness adjustment means The contents of the supply voltage which the aforementioned LSI circuit tester supplies to the aforementioned examined semiconductor device, and a test vector sequence are received as contents of electric control. And/ Or secondary electron image observation equipment characterized by deriving the lightness control value which receives the contents of the control signal which the aforementioned electron beam system control means give to the aforementioned electron beam system as image observation condition data, and is given to the aforementioned image data acquisition means with reference to these data.
[Claim 2] The aforementioned lightness adjustment means is secondary electron image observation equipment according to claim 1 characterized by acquiring the aforementioned contents of electric control, and the aforementioned image observation condition data from the aforementioned LSI circuit tester and the aforementioned electron beam system control means, respectively.
[Claim 3] It is secondary electron image observation equipment according to claim 1 carry out the control signal which the aforementioned electron beam system control means give to the aforementioned electron beam system being determined based on directions of a manual operation input means, and the aforementioned lightness adjustment means acquiring the aforementioned image observation condition data from the aforementioned operation input means, and acquiring the aforementioned contents of electric control from the aforementioned LSI circuit tester as the feature.
[Claim 4] The supply voltage and the test vector sequence which the aforementioned LSI circuit tester supplies to the aforementioned examined semiconductor device, and the control signal which the aforementioned electron beam system control means give to the aforementioned electron beam system are secondary-electron image observation equipment according to claim 1 it is determined based on the test control signal and the electron beam system motion-control signal which are given from analysis control means, respectively, and carry out that the aforementioned lightness adjustment means acquires the aforementioned contents of electric control, and the aforementioned image observation condition data from the aforementioned analysis control means, respectively as the feature.
[Claim 5] The aforementioned lightness adjustment means is secondary electron image observation equipment according to claim 1, 2, 3, or 4 characterized by having the function held with the content of

electric control when the secondary electron picture signal which this image data acquisition means supplies to the aforementioned display unit is acquired from the aforementioned image data acquisition means and this secondary electron picture signal or its lightness is supplied to this secondary electron picture signal, and image observation condition data.

[Claim 6] The secondary electron image observation method characterized by adjusting the lightness of the secondary electron image displayed on a display unit corresponding to the change when the supply voltage and the test vector sequence which an LSI circuit tester impresses to an examined semiconductor device are supervised as contents of electric control and the data of these contents of electric control change.

[Claim 7] The secondary electron image observation method according to claim 6 characterized by adjusting the lightness of the secondary electron image displayed on a display unit according to the change when the control signal which electron beam system control means give to an electron beam system is supervised as image observation conditions and the image observation condition data is changed.

[Claim 8] The secondary electron image observation method according to claim 6 or 7 characterized by adjusting the lightness of the secondary electron image which supervises the electron beam irradiation time to the Observations Department grade of an examined semiconductor device, and is displayed on a display unit according to the time.

[Claim 9] The secondary electron image observation method according to claim 6, 7, or 8 characterized by holding as a table the relation between change of the aforementioned contents of electric control, and the lightness control value change which should be performed corresponding to this, and adjusting lightness with reference to this.

[Claim 10] The relation between change of the aforementioned contents of electric control, and the lightness control value change which should be performed corresponding to this, The relation between change of the aforementioned image observation condition data and the lightness control value change which should be performed corresponding to this, And the secondary electron image observation method according to claim 7 or 8 characterized by holding the relation between the irradiation duration of an electron beam, and the lightness control value change accompanying this as a table, and adjusting lightness with reference to this.

[Claim 11] When it asks for the conversion table showing the relation between a lightness control value change and change of the lightness based on this beforehand and a suitable lightness distribution is not obtained in the process of secondary electron image observation The secondary electron image observation method according to claim 10 or 11 characterized by changing the data of a table while the amount of lightness control value changes required to obtain a suitable lightness distribution is obtained from a conversion table and this changes a lightness control value.

[Claim 12] 6, 7 and 8 which are characterized by carrying out contrast adjustment while adjusting lightness, or the secondary electron image observation method given in nine.

[Translation done.]

* NOTICES *

TECHNICAL FIELD

[The technical field to which invention belongs] this invention relates to the image observation method performed using the secondary electron image observation equipment and it which were made as [perform / lightness adjustment / automatically / as especially image observation can carry out in the state of suitable lightness / about the observation method of the equipment which observes the image of the secondary electron which irradiates an electron beam on the surface of a semiconductor device, and is generated by this, and a secondary electron image,].

[Translation done.]

* NOTICES *

PRIOR ART

[Description of the Prior Art] Conventionally, the electron beam tester (electron beam tester) is used as one of the failure analysis of a semiconductor device, or the effective meanses of device design verification. An examined semiconductor device is carried in a vacuum chamber, and it irradiates, scanning an electron beam to a part of examined semiconductor device two-dimensional, and the secondary electron image which expresses the configuration of an examined semiconductor device by the shade can be acquired by measuring the amount of secondary electrons which this generates. The secondary electron image which expresses the potential distribution of an examined semiconductor device front face by light and darkness by acquiring a secondary electron image can be acquired impressing supply voltage and a test vector sequence to an examined semiconductor device by the LSI circuit tester etc. especially, relative potential can be read in the gradation about each wiring in it, and High or Low can be judged when it is especially the logic LSI. Thus, failure analysis and analysis of operation can be performed by checking the potential of operation inside a semiconductor device.
[0003] In this case, the watcher has performed adjustment of the lightness on the display picture of a secondary electron image with hand control conventionally. Drawing 7 is the block diagram showing the composition of conventional secondary electron image observation equipment. In this drawing, 700 of a point within the limit is an electron beam tester, and 701 is an LSI circuit tester. In the electron beam tester 700, it has the vacuum chamber 703, the secondary electron detector 705 is arranged with the electron beam generation source 704 in the interior, and the electron beam system is constituted by these. Into the vacuum chamber 703, the examined semiconductor device 706 is placed as a candidate for observation. The fixture and the interconnection cable 702 connect between the examined semiconductor device 706 and the LSI circuit tester 701. The electron beam tester 700 is further equipped with the operation input means 707, the electron beam system control means 708, the image data acquisition means 709, and the display unit 711.
[0004] To the examined semiconductor device 706, supply voltage and a test vector sequence are impressed from the LSI circuit tester 701 through a fixture and an interconnection cable 702. According to the contents of an operation input by the watcher in the operation input means 707, the electron beam system control means 708 control physical operation and secondary electron detection of electron beam irradiation etc., and control secondary electron image acquisition. Under this control, from the electron beam generation source 704 in the vacuum chamber 703, an electron beam is generated and it scans including the Observations Department grade of the front face of the examined semiconductor device 706. A secondary electron occurs according to the surface configuration and surface potential to scan, and the secondary electron detector 705 incorporates the secondary electron which this generated, and counts the amount of secondary electrons. And it sends to the image data acquisition means 709 by making this measurement value into a detecting signal.
[0005] The image data acquisition means 709 receives the detecting signal from the secondary electron detector 705, and forms a secondary electron image in the bottom of control of the electron beam system control means 708 based on the lightness control value inputted from the operation input means 707. The

information is sent to a display unit 711, and is displayed as a picture. A watcher views this image display and the suitable content of correction is inputted into the operation input means 707.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] As explained above, since the secondary electron image observation equipment and the method of this invention adjust lightness and contrast corresponding to change of the contents of electric control, and image acquisition conditions, they can conform to change of the contents of electric control, and image acquisition conditions, and can always perform image observation on optimal lightness and contrast conditions. Therefore, according to this invention, device design verification and failure analysis can be performed efficiently. Moreover, according to this invention, adjustment of lightness and contrast is easily automatable.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] As for the secondary electron image mentioned above, overall lightness and contrast of an image are sharply changed by the electrical condition (****** [impressing supply voltage] etc.) of an examined semiconductor device, the conditions of image observation, the histories (the conditions of the image formation from the electron beam irradiation method and the amount of secondary electrons, the range for observation of an examined semiconductor device, etc.) of beam irradiation, etc. Furthermore, a lightness distribution of a secondary electron image will change, even while continuing observation of the same conditions. It is because the density of the electron of an examined semiconductor device front face changes and lightness and contrast change with elapsed time by continuing irradiation of an electron beam. Since an electron beam will irradiate the narrow range when a scale factor is gathered and observed especially, the density of a beam increases and this phenomenon becomes more remarkable. When the secondary electron image which is not suitable is acquired, on the whole, a lightness distribution inclines toward black or white, and it becomes impossible to read clearly the configuration of the examined semiconductor device front face originally needed, and a potential distribution.
[0007] In this case, when image observation is being performed on real time, it is possible to perform lightness adjustment manually, observing an image and to acquire suitable lightness. However, in failure analysis, a huge test vector sequence is impressed by the LSI circuit tester, and secondary electron image acquisition is performed in many cases only synchronizing with the test vector of the specific turn in it. In this case, although a test vector sequence will be impressed repeatedly and only the image data of specific timing will be acquired and accumulated in one data acquisition since the picture of high S/N cannot be acquired, since operation of reaccumulating image data must be repeated and must be again performed with another control value after doing in this way and accumulating when lightness is not appropriately adjusted in this observation mode, efficient failure analysis cannot be performed. Then, to automate adjustment of lightness and contrast for more efficient failure analysis is desired. Therefore, the technical problem of this invention is enabling it to adjust lightness and contrast of a secondary electron image quickly and automatically.

[Translation done.]

* NOTICES *

MEANS

[Means for Solving the Problem] The electron beam system which equips an examined semiconductor device with the electron beam generation source which irradiates an electron beam, and the secondary electron detector which detects the generated secondary electron according to this invention in order to solve the above-mentioned technical problem, The electron beam system control means which control the aforementioned electron beam system, and the LSI circuit tester which impresses supply voltage and a test vector sequence to an examined semiconductor device, An image data acquisition means to supply a secondary electron picture signal to the aforementioned display unit based on the detecting signal of the aforementioned secondary electron detector in order to display a secondary electron image on a display unit, It has a lightness adjustment means to direct the lightness of the secondary electron image which gives a lightness control value control value to the aforementioned image data acquisition means, and is displayed on a display unit. the aforementioned lightness adjustment means The content of the supply voltage which the aforementioned LSI circuit tester supplies to the aforementioned examined semiconductor device, and a test vector sequence is received as a content of electric control. And/ Or the content of the control signal which the aforementioned electron beam system control means give to the aforementioned electron beam system is received as image observation condition data, and secondary electron image observation equipment ** characterized by creating the lightness control value given to the aforementioned image data acquisition means with reference to these data is offered.
[0009] Moreover, according to this invention, in order to solve the above-mentioned technical problem, the supply voltage and the test vector sequence which an LSI circuit tester impresses to an examined semiconductor device are supervised as contents of electric control, and when the data of these contents of electric control change, secondary electron image observation method ** characterized by adjusting the lightness of the secondary electron image displayed on a display unit corresponding to the change is offered. And the image observation conditions which electron beam system control means give to an electron beam system are supervised preferably, and when the image observation condition is changed, the lightness of the secondary electron image displayed on a display unit according to the change is adjusted. Moreover, preferably, the electron beam irradiation time to the Observations Department grade of an examined semiconductor device is supervised, and the lightness of the secondary electron image displayed on a display unit according to the time is adjusted.
[0010]
[Embodiments of the Invention] Next, the form of operation of this invention is explained in detail with reference to a drawing.
[Form of the 1st operation] drawing 1 is the block diagram showing the form of operation of the 1st of this invention. a portion equivalent to the portion of the conventional example shown in drawing 6 in this drawing -- lower -- the reference number in which 2 figures is common should give -- ********** In the form of this operation, in the electron beam tester 100, the lightness control value which directs the lightness of the secondary electron image displayed on a display unit 111 is created, and a lightness adjustment means 110 to output this to the picture acquisition means 109 is established.

[0011] The LSI circuit tester 101 sends the contents of electric control (existence of power supply impression, address information of the test vector sequence to impress, etc.) given to the examined semiconductor device 106 for control value derivation of the lightness in the lightness adjustment means 110 to the lightness adjustment means 110. The electron beam system control means 108 send the control signal for controlling physical operation and secondary electron detection of electron beam irradiation etc. to an electron beam system according to the content of an input of operation by the watcher in the operation input means 107. Under this control, from the electron beam generation source 104 in the vacuum chamber 103, an electron beam is generated and it scans including the Observations Department grade of the front face of the examined semiconductor device 106. A secondary electron occurs according to the surface configuration and surface potential to scan, and it is detected by the secondary electron detector 105. Moreover, the electron beam system control means 108 send the control signal for controlling secondary electron image acquisition to the image data acquisition means 109. Furthermore, the electron beam system control means 108 send image observation conditions (the scale factor of image observation, image observation time, etc.) to the lightness adjustment means 110.
[0012] The image data acquisition means 109 receives the content of electron beam system control from the electron beam system control means 108 as a control signal, receives the information on a secondary electron from the secondary electron detector 105 as a detecting signal, and according to the lightness control value from the lightness adjustment means 110, after setting up lightness, it forms a secondary electron image. Refer to the content of electric control from the LSI circuit tester 101 to the secondary electron image formed with the image data acquisition means 109, and the examined semiconductor device 106, and the image observation conditions in the electron beam system control means 108 for the lightness adjustment means 110. Here, the electron beam irradiation time continued by the same field is also contained in image observation conditions. A suitable lightness control value is drawn based on these, and it is sent to the image data acquisition means 109. By sending a suitable lightness control value by the above procedure, the lightness of a secondary electron image will become good, and from the image data acquisition means 109, a secondary electron image is sent to a display unit 111, and it is displayed as a picture. The secondary electron image created with the image data acquisition means 109 is sent also to the lightness adjustment means 110, and is used here for lightness surveillance.
[0013] In addition, the vacuum chamber 103, the electron beam generation source 104, the secondary electron detector 105, the electron beam system control means 108, the image data acquisition means 109, and a display unit 111 should just be mechanisms equivalent to the thing in the electron beam tester 100 marketed. However, in the electron beam system control means 108 and the image data acquisition means 109, the mechanism of data transmission and reception with the lightness adjustment means 110 is added to the equivalent function in the commercial electron beam tester 100.
[0014] Change is added to the gestalt of the 1st operation mentioned above, and you may make it the lightness adjustment means 110 acquire image observation conditions from the operation input means 107. In this case, the operation input means 107 derives image observation conditions from the content of operation given to the electron beam system control means 108.
[0015] [Form of the 2nd operation] drawing 2 is the block diagram showing the form of operation of the 2nd of this invention. the portion equivalent to the form of the 1st operation shown in drawing 1 in this drawing -- lower -- the reference number in which 2 figures is common should give -- ********** In the form of this operation, analysis operation is automatically performed by controlling an electron beam tester 200 and the LSI circuit tester 201 by the computer etc. That is, an electron beam system motion-control signal is given to the electron beam system control means 208 from the analysis control means 212 which control the whole automatic analysis operation, and a test control signal is given to the LSI circuit tester 201. From the contents of the test control signal to the LSI circuit tester 201, the analysis control means 212 draw the contents of electric control sent to the examined semiconductor device 206 from the LSI circuit tester 201, and send the data to the lightness adjustment means 210. Moreover, image observation conditions are drawn from the contents of control to the electron beam system control means 208, and it sends to the lightness adjustment means 210. Other composition is the

same as that of the form of the 1st operation shown in drawing 1 . It is not necessary to make the need of making image observation conditions outputting from the electron beam system control means 208 according to the composition of the form of this 2nd operation, and the contents of electric control from the LSI circuit tester 201 to the examined semiconductor device 206 output, and if the means of motion control against an electron beam tester 200 and the LSI circuit tester 201 is used, it can carry out, without requiring the special reconstruction to each.

[0016] The example of concrete operation of the secondary electron image observation equipment shown in [Operation] next drawing 1 , and drawing 2 is explained. Drawing 3 is a flow chart which shows the example of the procedure of the lightness adjustment performed by taking and being in the observation equipment shown in drawing 1 and drawing 2 . In advance of image observation, the data which change with the contents of electric control and image acquisition conditions and correlation with the average variation of the lightness control value by the difference of electron beam irradiation time understand beforehand are acquired using the sample semiconductor device etc., and it is stored as a table which should be referred to.

[0017] In case a secondary electron image is observed, in advance of observation, adjustment start instructions are emitted by the lightness adjustment means 108 from the electron beam system control means 108 (or the publication of the reference number of the base of No. 200 is omitted suitably 208 and the following), and the flow of drawing 3 is started. Here, the voltage impressed to the examined semiconductor device 106 in the image (or carried out actually) observation performed last time as an example and the image observation performed from now on changes to 3V from 0V, and a change mentions the case where there is nothing to the other conditions. First, the contents of electric control in the case of the image observation performed last time, image acquisition conditions, and the lightness control value at that time are read and held at Step S1.

[0018] Next, in Step S2, the image observation conditions based on the control signal which acquires the supply voltage and the test vector sequence which are impressed to the examined semiconductor device 106 as contents of electric control from the LSI circuit tester 11, and is given to an electron beam system from the electron beam system control means 108 about the secondary electron image observation to be performed from now on are acquired from the electron beam system control means 108, and this is held. Subsequently, comparison of the contents of electric control of this time and last time and image acquisition conditions is performed at Step S3. In the case of the above-mentioned example, it is recognized that applied voltage changes to 3V from 0V. And the optimal amount of lightness control value changes corresponding to the difference at Step S3 is calculated at Step S4. For this reason, the contents of the table on which the data showing the optimal amount of lightness control value changes when it changes for every conditions are stored are investigated. The example of data is shown in drawing 4 . A difference of the optimal lightness control value at the time of impression of voltage 3V and powering off is 6. Supposing the applied voltage in the time of the last image observation is 0V and was adjusted to the lightness distribution with the lightness control value optimal at 180, the optimal lightness control value after voltage 3V impression will be drawn as 186 (=180+6).

[0019] The lightness control value drawn at Step S4 is transmitted to the image acquisition means 109 at Step S5, and lightness adjustment operation by the lightness adjustment means 110 is completed. Then, the supply voltage and the test vector sequence which were directed for this observation are impressed to the examined semiconductor device 106 from the LSI circuit tester 101, an electron beam system performs operation which followed the control signal from the electron beam system control means 108, and the detecting signal outputted based on this is sent to the image data acquisition means 109. After this detecting signal is processed into a secondary electron image according to the lightness control value newly inputted in the image data acquisition means 109, it is sent to a display unit 111 and displayed on a screen.

[0020] In observation of a secondary electron image, there is a phenomenon in which lightness changes, by continuing irradiation of an electron beam to the same Observations Department grade. That is, the lightness control value for keeping a lightness distribution of an image the optimal also changes with time.

Furthermore, the rate of the change per the same time changes also with scale factors. When gathering the observation scale factor of a secondary electron image, and an electron beam scans a narrow field, it is for the rate of change of the electron density of the examined semiconductor device 106 by the density of the electron of a beam becoming high and continuing irradiation to increase. In this invention, in order to cope with this phenomenon, progress of electron beam irradiation time and a relation with the optimal amount of lightness control value changes are investigated beforehand, and the data is held in the table. With this, the time (second) per variation of the optimal lightness control value for every scale factor is investigated in advance, and the data is held in the table.

[0021] Drawing 5 is the example of the data which expressed the time (second) per variation of the optimal lightness control value for every scale factor. For example, when observing a scale factor in 500 times, the optimal lightness control value will decrease every [0.4] per time. When observation should be continued for this scale factor, the flow of drawing 3 will be performed and the comparison result in Step S3 will perform now image observation in the state where beam irradiation time is long, for 3 seconds from last time, the lightness control value which lowered only 0.4x3= 1.2 at Step S4 is drawn.

[0022] Moreover, when carrying out image observation, changing the irradiation position and irradiation time of an electron beam moving the Observations Department grade, amendment is added [as opposed to / a lightness control value / only in the part according to elapsed time and a scale factor after moving the Observations Department grade to the part] with reference to drawing 5 . For example, if the flow of drawing 3 should be performed when it observed after [of an after / the Observations Department grade movement] 5 seconds to Field A and an image was observed for the Observations Department grade by one 500 times the scale factor of this after / of an after / movement] 20 seconds to Field B last time this time In Step S3, there is no change in a scale factor, and a ******** is detected [20-5= 15 (second)] for the electron beam irradiation time in Field B from the irradiation time in Field A. Consequently, the lightness control value which lowered only 0.4(20-5) = 6 from the case of Field A with reference to the data of drawing 5 at Step S4 is drawn.

[0023] The data shown in [correction of reference table] drawing 4 and drawing 5 show the average value measured and acquired about the sample etc. in advance. However, in other factors, such as a difference of the property of the front face of each examined semiconductor device, and a difference of the state of the filament of an electron beam generation source, for a certain reason, the case where already acquired data are not suitable to substance may happen in fact. Then, after drawing the lightness control value of initial value at the Observations Department grade, it is good to give fine tuning considered to be suitable, to obtain a proper lightness distribution, and to use this result in future lightness adjustments. A concrete procedure for that is shown in drawing 6 .

[0024] In the flow of drawing 6 , since the process to Step S4 is the same as the process shown in drawing 3 , the explanation is omitted. The lightness control value drawn at Step S4 is sent out in Step S5 to the image data acquisition means 109. Here, as explained previously, last image observation should be performed by voltage:0V and lightness control value:180, and 186 should be sent out for this image observation as a lightness control value by applied-voltage:3V. The image data acquisition means 109 creates a secondary electron image (a secondary electron image is specifically bit map data, i.e., the digital data for a pixel) based on the detecting signal of an electron beam system, and the sent lightness control value, and sends this out to a display unit 111 and the lightness adjustment means 110. In Step S6, the lightness adjustment means 109 creates a lightness distribution map, i.e., a lightness histogram, based on the sent secondary electron image. Next, it is judged in Step S7 whether the obtained lightness distribution is proper. This is judged by whether there is any mean value of for example, a lightness histogram within suitable limits. When the suitable lightness distribution is obtained, processing is ended, and when that is not right, it moves to Step S8.

[0025] In Step S8, the variation of the lightness for obtaining a suitable lightness distribution is calculated, and a new lightness control value is drawn based on this. Here, the variation of the lightness for obtaining a suitable lightness distribution is determined by which should change the mean value of for example, a lightness histogram. And the amount of lightness control value changes is determined with

reference to the lightness control value variation / lightness variation conversion table currently prepared beforehand. Generally, since a correlation is between the variation from a certain lightness control value, and the variation of lightness, only a certain amount can convert [which should change a lightness control value to changing lightness, and]. Then, in this invention, this conversion table is prepared, and it uses in order to derive a better lightness control value. Next, in Step S9, the table for calculating a lightness control value is rewritten based on the newly drawn lightness control value. For example, in the above-mentioned example (applied voltage : 3 V, a lightness control value : 186), when it is determined that a lightness control value should be made 185, the amount of differences of the lightness control value corresponding to 3V of the data shown in drawing 4 is rewritten to 5. Then, it returns to Step S5 and process after it is performed.

[0026] Hereafter, this rewritten table is used and subsequent image observation is performed. That is, it observes, rewriting a table if needed. In addition, although explanation followed the contents of electric control of the data impressed to an examined semiconductor device, it is the same also about the image observation conditions containing electron beam irradiation time.

[0027] As mentioned above, although the form of desirable operation was explained, a proper change is possible for this invention within limits which are not limited to these and indicated by the claim. Moreover, although the form of operation explained as what adjusts only the lightness of a secondary electron image, you may make it adjust the contrast of a picture independently in addition to lightness.

[Translation done.]

* NOTICES *

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The block diagram showing the gestalt of operation of the 1st of this invention.
[Drawing 2] The block diagram showing the gestalt of operation of the 2nd of this invention.
[Drawing 3] The flow chart for explaining operation of the 1st of this invention, and the gestalt of the 2nd operation.
[Drawing 4] Drawing showing the data for explaining operation of the 1st of this invention, and the gestalt of the 2nd operation.
[Drawing 5] Drawing showing the data for explaining operation of the 1st of this invention, and the gestalt of the 2nd operation.
[Drawing 6] The flow chart for explaining operation of the 1st of this invention, and the form of the 2nd operation.
[Drawing 7] The block diagram showing the conventional example.
[Description of Notations]
100,200,700 Electron beam tester
101, 201, 701 LSI circuit tester
102, 202, 702 Interconnection cable
103, 203, 703 Vacuum chamber
104, 204, 704 Electron beam generation source
105, 205, 705 Secondary electron detector
106, 206, 706 Examined semiconductor device
107 707 Operation input means
108, 208, 708 Electron beam system control means
109, 209, 709 Image data acquisition means
110 210 Lightness adjustment means
111, 211, 711 Display unit
212 Analysis Control Means

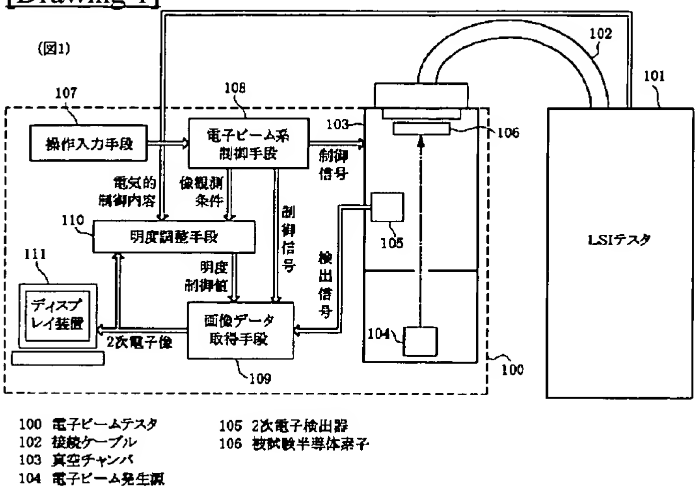
[Translation done.]

* NOTICES *

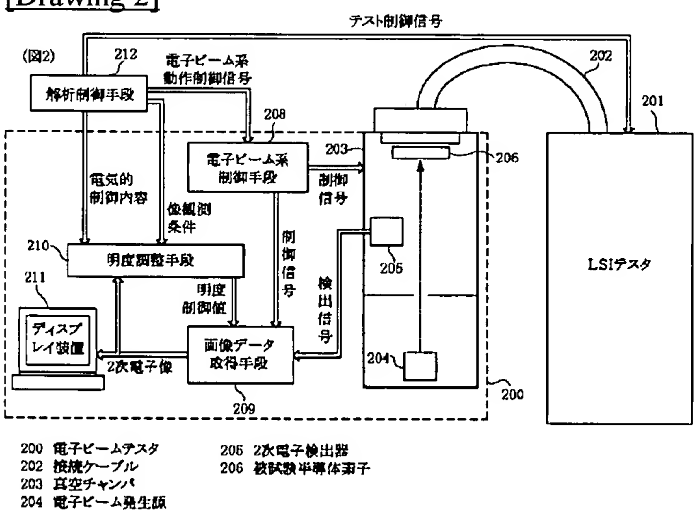
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

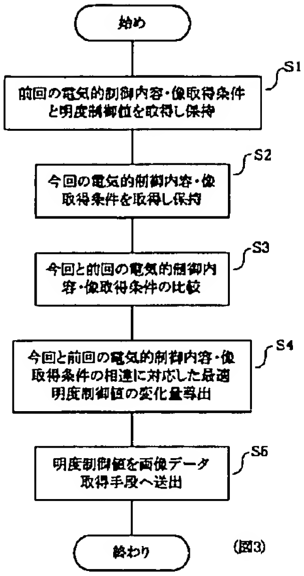
[Drawing 1]



[Drawing 2]



[Drawing 3]



(図3)

[Drawing 4]

(図4)

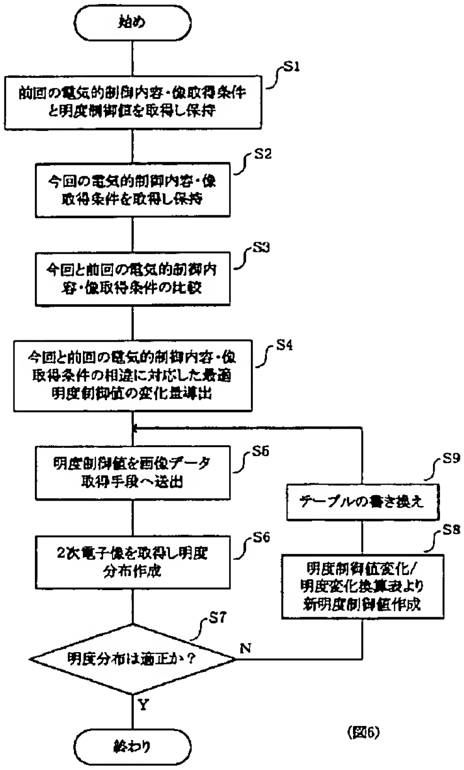
印加/切断電圧	明度制御値の相違量
0V	0
1V	2
2V	4
3V	6
4V	8

[Drawing 5]

(図5)

倍率	時間(秒)当たり明度制御値変化量
250	−0.16
353	−0.24
500	−0.4
707	−0.6
1000	−1

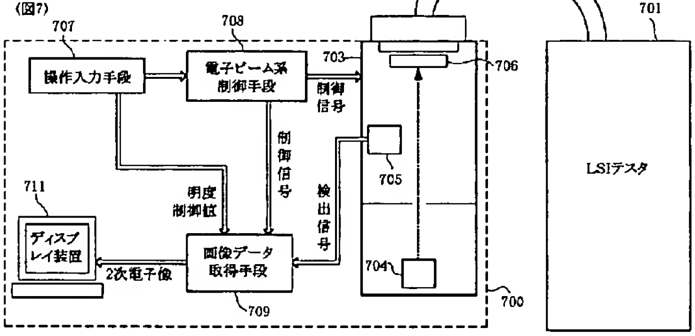
[Drawing 6]



(図6)

[Drawing 7]

(図7)



700 電子ビームテスタ
702 接続ケーブル
703 真空チャンバ
704 電子ビーム発生源
705 2次電子検出器
706 被試験半導体素子

[Translation done.]